

Introduction to Critical Care Management of Children With COVID-19

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COVID-19 may lead to critical illness in children, including hypoxemic respiratory failure, acute respiratory distress syndrome (ARDS), septic shock, cardiac dysfunction, thromboembolic disease, hepatic or renal dysfunction, central nervous system disease, and exacerbation of underlying comorbidities. In addition, multisystem inflammatory syndrome in children (MIS-C) is a rare, postinfectious complication of SARS-CoV-2 and is frequently associated with critical illness.

Data informing the optimal management of children with acute COVID-19 or MIS-C are limited. In general, management should follow the principles of pediatric critical care usually applied to non-COVID-19-related illness, such as the [Pediatric Acute Lung Injury Consensus Conference \(PALICC\) recommendations](#) and the [Surviving Sepsis Campaign International Guidelines for the Management of Septic Shock and Sepsis-Associated Organ Dysfunction in Children](#). For patients with COVID-19 in the intensive care unit (ICU), treatment often requires managing underlying illnesses other than COVID-19 that may have contributed to the need for ICU admission, as well as managing COVID-19 complications. Finally, prevention of ICU-related complications is critical to achieving optimal clinical outcomes for any patient admitted to the ICU.

Selected Clinical Manifestations of COVID-19 Critical Illness

Inflammatory Response

Patients with COVID-19 may develop a hyperinflammatory state, which appears to be distinct from classic “cytokine storm” syndromes (e.g., macrophage activation syndrome in juvenile idiopathic arthritis, familial hemophagocytic lymphohistiocytosis). This phenomenon is less well-described in children than in adults.

Multisystem Inflammatory Syndrome in Children

MIS-C is a rare, postinfectious complication of SARS-CoV-2 that is characterized by persistent fever, systemic inflammation, and multisystem organ dysfunction. The majority of children with MIS-C require ICU-level care, primarily for shock and for vasopressor and inotropic support.¹⁻³ For details on the definition of MIS-C, clinical features, and recommended treatments, see [Special Considerations in Children](#) and [Therapeutic Management of Hospitalized Pediatric Patients With Multisystem Inflammatory Syndrome in Children \(MIS-C\) \(With Discussion on Multisystem Inflammatory Syndrome in Adults \[MIS-A\]\)](#).

Cardiac Dysfunction, Including Myocarditis

Although cardiac involvement is common in patients with MIS-C,^{2,4} cardiac manifestations have rarely been described in children with acute COVID-19. Myocarditis, cardiac conduction abnormalities, and coronary artery aneurysms have been reported in patients with MIS-C. Myocarditis may also occur after SARS-CoV-2 vaccination, particularly in adolescent males, although the clinical course generally is relatively mild.⁵

Thromboembolic Events

Limited data characterize the prevalence of thromboembolic disease in children with COVID-19 or MIS-C. In a multicenter, retrospective cohort study including 814 hospitalized patients with COVID-19

or MIS-C, thromboembolic events were detected in 2.1% of patients with COVID-19 and 6.5% of patients with MIS-C.⁶ The same study conducted a multivariable analysis and found that the following variables were associated with increased risk of thromboembolic events: children aged ≥ 12 years, MIS-C, central venous catheters, and underlying malignancies. See [Antithrombotic Therapy in Patients With COVID-19](#) for additional recommendations.

Acute Kidney Injury

Acute kidney injury is estimated to occur in 12% to 44% of hospitalized children with COVID-19 or MIS-C, but the need for renal replacement therapy is extremely rare.⁷⁻¹⁰

Neurologic Involvement

Neurologic involvement is common in children with COVID-19 or MIS-C and is estimated to occur in approximately 30% to 40% of children hospitalized with these conditions.^{2,11} Severe neurologic manifestations, including severe encephalopathy, stroke, demyelinating conditions, cerebral edema, and Guillain-Barré syndrome, have also been described.¹¹

Important Considerations in the Care of Critically Ill Patients With COVID-19

Considerations for the care of children with COVID-19 or MIS-C should generally follow the usual principles of pediatric critical care. Sedation management and considerations related to post-intensive care syndrome–pediatric (PICS-p) are discussed below. See [Oxygenation and Ventilation for Children](#), [Hemodynamic Considerations for Children](#), and [Extracorporeal Membrane Oxygenation for Children](#) for more information on pediatric critical care.

Sedation Management

Guidelines for the management of pain, agitation, neuromuscular blockade, delirium, and early mobility (PANDEM) in infants and children admitted to the pediatric ICU have recently been published.¹² In general, children with COVID-19 or MIS-C who require mechanical ventilation should be managed per the usual critical care for patients with respiratory failure who require mechanical ventilation. The usual care includes sedation with the minimal effective dose required to tolerate mechanical ventilation, optimize gas exchange, and minimize the risk of ventilator-induced lung injury. Using validated pain and sedation scales, the critical care team should set a sedation/pain target based on the phase of ventilation.

Two large randomized controlled trials examined the use of protocols to manage sedation titration in children receiving mechanical ventilation.^{13,14} In both studies, participants received usual care or protocol-driven care implemented by nurses. The studies found that the use of the protocols did not demonstrate a significant benefit on outcomes, such as the duration of ventilation. However, a patient's risk of harm from protocolized sedation is generally low, which led the Society of Critical Care Medicine to issue a conditional recommendation, based on low-level evidence, in its PANDEM clinical practice guidelines suggesting the use of protocolized sedation in children who are critically ill and receiving mechanical ventilation.¹²

Studies evaluating data on the effect of early mobility protocols on critically ill children are limited. One trial evaluated the safety and feasibility of early mobilization in 58 patients who were randomized to receive usual care or early physical therapy, occupational therapy, and speech therapy consultation within 72 hours of admission to the pediatric ICU.¹⁵ Although no differences between the arms were demonstrated for clinical, functional, or quality of life outcomes, the study found that the early rehabilitation consultations were safe and feasible.

Ongoing trials are measuring the effect of early mobilization on patient-centered outcomes in children

receiving mechanical ventilation. The PANDEM guideline statement issued by the Society of Critical Care Medicine conditionally recommends, based on a low quality of evidence, implementing early mobilization strategies in children when feasible, which likely would apply to children with COVID-19 or MIS-C.¹²

Post-Intensive Care Syndrome

In recent years, there has been a growing awareness that PICS can occur in pediatric patients. PICS-p has been demonstrated to have a multifaceted effect on the physical, cognitive, emotional, and social health of child survivors of critical illness and their families.¹⁶ Furthermore, many pediatric survivors of sepsis or ARDS manifest significant impairments in physical, cognitive, and emotional health.¹⁷⁻¹⁹ Although no clear data characterize the prevalence of PICS-p or long-term morbidity in children with COVID-19 or MIS-C, the prevalence is expected to be similar to that observed in other populations with similar illness severities.

Acknowledgments

For these pediatric recommendations, the COVID-19 Treatment Guidelines Panel integrated the recommendations from pediatric-specific guidelines, including the European Society of Paediatric and Neonatal Intensive Care's recommendations²⁰ for the care of critically ill children with COVID-19 and the Surviving Sepsis Campaign's perspective on managing sepsis in children with COVID-19.²¹ In addition, recommendations from several non-COVID-19-specific treatment guidelines, such as the *Surviving Sepsis Campaign International Guidelines for the Management of Septic Shock and Sepsis-Associated Organ Dysfunction in Children*,²² the PALICC recommendations,²³ and the Society of Critical Care Medicine's PANDEM guidelines,¹² were integrated.

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